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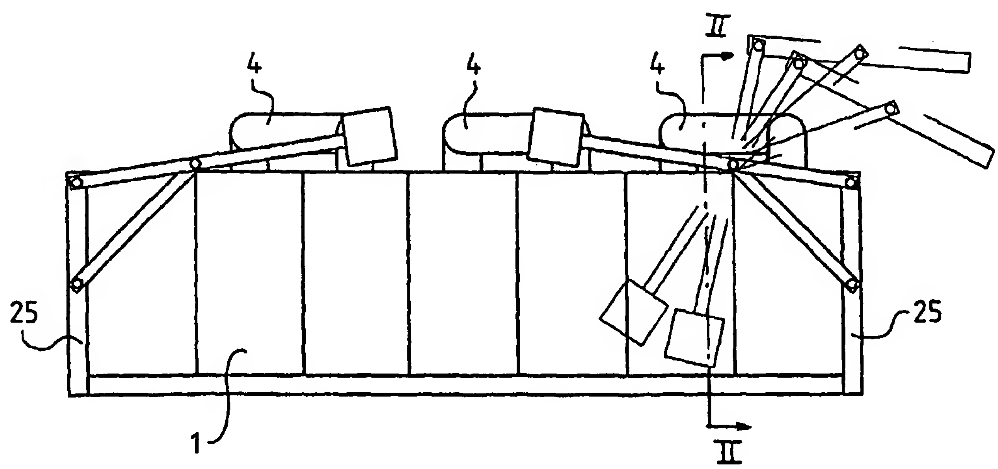

(57) Abstract: The disclosure relates to a method and apparatus for drying wood (3). The drying takes place in a closed drying chamber (1) with the aid of elements (2) which emit radiation energy. The radiation is of such wavelength that it is absorbed by the water molecules in the wood, while the remainder of the wood is substantially unaffected. In order to control the drying, a number of indicators (7, 10) are provided which sense temperature and moisture within at least one of the wood parts (3) as well as temperature and relative humidity in the drying chamber (1). The interior of the drying chamber (1) consists of a material displaying high reflectance. The drying chamber further has a circulation fan (4) and a ventilation damper (14).

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A METHOD AND AN APPARATUS FOR DRYING WOOD

TECHNICAL FIELD

The present invention relates to a method and an apparatus for drying wood with the aid of thermal radiation, employing air which passes the wood.

BACKGROUND ART

In the drying of wood, the objective is to reduce the moisture ratio of the wood to a level which is suitable for the contemplated field of use.

The moisture ratio is generally defined as follows:

Moisture ratio=$(m-m_0)/m_0$, where m_0 is the dry weight of the wood and m is the weight of the relevant wood. In standard tables, there is information relating to the dry weights of different wood types. Room-dry wood, i.e. wood for indoor use, for example floors, joinery, furniture etc., should have a moisture ratio of 6-10%, building timber for indoor use should have a moisture ratio of 12-14% and shipping-dry wood should have a moisture ratio of approx. 16-18%.

In order, to the greatest possible extent, to avoid negative action such as deformation of the wood or crack formation in it, the drying process must be adapted to the type of wood, dimensions, desired moisture ratio etc. It is known that if the drying process is carried out at an excessively high temperature in order to shorten the drying time, deformations or crack formations generally occur in the wood. This is because, in the drying process, the cells of the wood are heated to temperatures at which they shut off the passages through which vaporised water or steam may pass.

The water in the wood (the timber or wood) is in both so-called free and bonded form. The free water is in the

cavities of the cells, while the bonded water is chemically bonded in the cell walls. In drying, the free water is given off first. At the so-called fibre saturation point, which for most wood types lies at a moisture ratio of 23-28%, as good as all free water is removed, while the cell walls have a maximum moisture content. On drying below the fibre saturation point, it is, thus, the bonded water that is removed from the wood.

Ideally, the aim is that "all moisture" i.e. water which departs from the wood, should not be bonded to any other substances such as acids etc., since the intention is that these substances are to remain in the wood, since they contribute to maintaining its quality. The lower the temperature maintained in the drying process, the smaller will be the quantity of substances accompanying the moisture out.

For wood, there is a general curve described in the literature for the moisture ratio at equilibrium at different dry and wet temperatures/relative humidities. The moisture ratio at equilibrium is the moisture ratio of material which is in a state of equilibrium with its ambient surroundings. For wood, the moisture ratio at equilibrium is thus affected by the relative air humidity in ambient air and its dry and wet temperature. In principle, the relationships are such that if the aim is to reduce the relative air humidity of the air surrounding the wood, the moisture ratio at equilibrium in the wood will be reduced. The lower the moisture ratio at equilibrium is, the "drier" the wood.

In those timber sizes available today, drying most generally takes place in that heated air is caused to circulate around flat-stacked timber. The temperature and air humidity of the heated air is then progressively changed in order that the timber obtain the desired moisture ratio at the same time as the timber will have, hopefully, as few

cracks and deformations as possible. The air temperature is regulated by flue gas heat, steam or electric heating and the air circulation is governed by a fan system. However, the temperatures employed often result in the areas most proximal the surface of the timber forming a liquid-tight layer which prevents the moisture from the inner areas reaching the surface of the timber.

Because of the relatively lengthy drying time in the employment of prior art methods, there is always a general need in the art to be able to shorten the drying time and still maintain the same quality or preferably improve the quality of the dried timber.

One general need in the art is that energy consumption in the drying process should be as low as possible.

The above advantages and needs are attained using a method and an apparatus according to the appended independent claims. The subclaims disclose expedient embodiments of the present invention. Further advantages inherent in the present invention will be apparent from the detailed description below.

OUTLINE OF THE INVENTION

The present invention is based on the concept of only employing radiation energy (thermal radiation) for heating the wood and that the radiation employed encompasses a wave length range within which water has its highest absorption coefficient and that the temperature of the air which passes the wood during the drying phase of the wood is periodically lower or equal to the temperature of the wood.

Thermal radiation has the characteristic property that it requires no medium for transferring energy between two bodies. This may be likened to the energy of the sun which is conveyed to the earth. In conventional timber drying, use is made of a thermal battery for heating the air and fans for supplying the air, and thereby the thermal en-

ergy, to the wood. With radiation energy in a narrow wavelength band where the water has a high absorption capability, the radiation energy is transmitted direct to the water molecules in the wood. This results in substantially shortened drying times, considerably less energy consumption and an improved quality of the dried wood.

Compared with prior art technology, the present invention discloses a method which makes it possible, in the drying operation, to work with a much higher relative humidity in the air surrounding the wood. By employing this high relative humidity, the quality of the dried wood will be improved.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

The present invention will now be described in greater detail hereinbelow, with the aid of a number of embodiments according to the accompanying Drawings. In the accompanying Drawings:

Fig. 1 shows one example of a drying apparatus including a drying chamber according to the present invention;

Fig. 2 is a section taken along the line II-II in Fig. 1;

Fig. 3 is an example of a rack with radiation sources according to the present invention;

Fig. 4 is a section taken along the line IV-IV in Fig. 3;

Fig. 5 is a section through one embodiment of a radiation source;

Fig. 6 is a perspective view of an alternative embodiment of a radiation source;

Fig. 7 is a perspective view of a drying stack; and

Fig. 8 is a block diagram showing one embodiment of a regulation function according to the present invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

The expression "element" 2 will be employed below to refer to a radiation source. The element is designed as a device which emits radiation comprising a selected wavelength region.

Figs. 1-2 show one embodiment of a drying apparatus including a drying chamber 1 in which the drying of the wood takes place. As a rule, the walls of the chamber are clad on the inside with stainless steel, aluminium or similar high-reflective material for radiation within the above-indicated selected wavelength region. In other words, the interior of the drying chamber is designed as a large reflector. The walls are generally thermally insulating.

The drying chamber 1 is disposed to accommodate drying stacks 6 which consist of timber 3 (Fig. 7) hereinafter also referred to as "wood", stacked in the customary manner with interjacent laths.

Figs. 3 and 4 show a schematic sketch of the construction of a rack 5 in which is included a number of elements 2. In certain practical applications, the rack is fixed in the drying chamber (Fig. 2), while, in other embodiments (Fig. 7), they are designed to be placed in the drying stacks 6. Fig. 4 shows an embodiment of a rack in which a reflector 20 is disposed behind each element 2.

In order to realise good reflection of the radiation, the reflectors are generally made of aluminium, stainless steel or other high-reflective material. As required, the racks 5 are provided with handles, suspension devices, electric sockets, recesses for fork-lift trucks, etc. Normally, the elements 2 are disposed in any optional direction whatever in relation to the longitudinal direction of the wood 3.

The drying apparatus is, in the illustrated embodiment, provided with a circulation fan 4 and a ventilation damper 14. The circulation fan 4 circulates the air in the

drying chamber and thereby conveys off moisture which departs from the surface of the wood. The ventilation damper 14 is employed for regulating the size of the current of air which is depart from the drying chamber and thereby the relative air humidity in the drying chamber 1. The temperature in the drying chamber 1 is governed with the aid of the elements 2. For accurate monitoring of the air humidity in the chamber, use is made of indicators 10 which measure the relative air humidity.

In the drying apparatus, there is disposed an indicator 9 for measuring the temperature in the drying chamber and/or of the air which departs from and/or is fed to the drying chamber. In addition, there are indicators 7 which measure the temperature of the wood 3. As a rule, the temperature is measured inside the wood and, in certain embodiments, indicators 7 which measure the temperature of the wood. In certain embodiments, there are also indicators 8 which measure the moisture ratio of the wood. This is generally measured inside the wood. Often, the indicators are placed in the centre of the wood, but this is not necessary since account is taken of the placing of the indicators when regulating the drying process.

In order to measure the moisture in the wood, use is made, in certain embodiments, of a weighing machine 27 where the difference between the measured weight and the weight of an ideal, dried wood gives the relevant moisture ratio.

The task of the fan system is to circulate the air around the wood 3 and thereby entrain moisture from the surface of the wood. In the present invention, use is normally made of a flow rate of 1-5 m/s, when the flow rate is measured, e.g. at the end of one or more drying stacks 6 or between drying stacks 6.

By suitable placing of the inlet and outlet of the fan system, it is possible to cause the air current to pass

through the drying stacks. By, moreover, reversing the flow direction in the fan system at regular intervals, there will be obtained a uniform distribution of the air humidity and temperature in the chamber.

The drying of wood may, in principle, be divided into three phases, namely heating of the wood, drying of the wood and after-treatment of the wood. In reality, the two first phases overlap each other, since already before the wood has, on heating, reached the temperature range within which the temperature is to be maintained during the drying operation, a transport of water vapour out of the wood begins even though, during the heating phase for the wood, the air humidity is kept so high that the air is substantially saturated.

It generally applies that, when radiation energy is supplied to the wood, the water molecules absorb the radiation energy in a surface layer of the wood. As a result, a heating takes place of the water in the surface layer. Since that radiation energy which is not absorbed by an individual molecule reaches other molecules once it has passed through the individual molecule or been reflected by it, the radiation energy is also absorbed by water molecules inside the surface layer. As a result, a heating of the water in wood inside the surface layer also takes place.

According to the present invention, periods during which the elements 2 are energised in order to emit thermal energy are alternated with periods during which the elements 2 are de-energised. During the "rest periods" of the elements 2, an equalisation takes place of the vapour pressure in that vaporised water migrates towards the surface of the wood from the interior of the wood. Hereby, the surface of the wood is kept moist. As a rule, the supply of energy to the wood is controlled such that, at least during a part of the drying phase, the surface of the wood is cov-

ered by a thin film of water. The drying process continues until the desired moisture ratio in the wood has been achieved.

When the water is heated, the water is vaporised and when the partial pressure (the pressure which the vaporised water generates) exceeds the vapour pressure of the ambient surroundings of the surface layer, the moisture ratio in that wood which contains vaporised water falls, i.e. in the wood which forms the surface layer. In a direction towards the centre of the wood, the surface layer interfaces (at least after some time) with wood having a greater moisture content. The water which is in the wood located inside the surface layer leads thermal energy from the surface layer towards the centre of the wood. As a result, a vaporisation takes place of water which is heated. When the partial pressure in the thus formed vapour becomes higher than the partial pressure in the surface layer, a certain equalisation takes place of the vapour pressure inside the surface layer (more proximal the centre of the wood) and in the surface layer. In other words, water vapour is moved into the surface layer and out from it through the surface of the wood.

On continued, regulated heating of water in the surface layer, energy is conveyed steadily further into the wood, the above-described cycle being repeated in regions steadily closer to the centre of the wood. When the temperature of the wood is at its highest in its centre, the partial pressure in the vaporised water is highest in the centre of the wood (theoretically) and lowest most proximal the surface of the wood. As a result, there occurs a transport of vaporised water from the centre of the wood. The transport of vaporised water to the surface of the wood is so efficient that the air humidity in the drying chamber 1 is substantially maintained by water or vaporised water which has departed from the wood.

During the later part of the heating phase and at least also during the initial part of the drying phase, the relative humidity in the ambient air is, in one preferred embodiment, kept at a level which is close to 100% and is generally located within the range of 99% to 100%. The just-disclosed values for relative humidity in the air are employed, for example, in the drying of pine or spruce. For other wood types, use is made of other levels which are located in the range from 85% to 100%.

Once the process has continued for a time, the temperature is, as has already been disclosed above, lower at the surface of the wood than in its interior. When the wood has reached a predetermined regulated temperature, the elements 2 are normally shut off, whereafter the surface of the wood cools more rapidly than its interior. Thereafter, the temperature of the wood is periodically kept at a level which corresponds to or exceeds the temperature of the ambient air. This takes place by controlled energisation and de-energisation of the elements 2. At the same time, the relative humidity of the ambient air is kept at a relatively high level. In the subsequent treatment, the level of the partial pressure of the vapour in the wood is, as a rule, so high that the partial pressure most proximal the surface of the wood exceeds the partial pressure which corresponds to the relative humidity of the ambient air. Reliable transport of water molecules from the surface of the wood to the air surrounding the wood is hereby achieved.

Fig. 8 shows one example of a regulator device for a drying apparatus according to the present invention. The signals from the various indicators 7-10, 27 in the drying chamber 1 are received and processed in a registration and calculation unit 12, hereafter referred to as PLC system 12. Depending upon the signals received, the wood type and the dimensions of the timber to be dried, the PLC system 12 then controls the elements 2, the ventilation damper 14, as

well as the circulation fan 4 so that the drying process described in the foregoing paragraph takes place. A person skilled in the art will perceive that, in principle, it is also possible to run the drying process manually by continuous monitoring of the values of the indicators.

The safety interface 26 in the control diagram is used for breaking the current supply to the elements 2 if any of the doors 25 in the drying chamber 1 is opened.

As has already been disclosed, the chamber 1 and the rack 5 containing the elements 2 are generally provided with reflectors of, e.g. aluminium or stainless steel sheet. In the frequencies employed, these materials display reflection coefficients exceeding 95%. Radiation which impinges on the reflectors is guided by them back to the timber. It is not a requirement that reflectors be employed, but they do contribute to a reduction in energy consumption.

According to the present invention, drying of the timber 3 takes place with the aid of elements 2 each one in an embodiment designed as an electric thermal coil 22, a tube 17, plates 18 or similar devices. These elements 2 emit a radiation in a limited wavelength interval adapted to the absorption of water. The generated radiation is absorbed direct or after reflection of water existing in the surface layer of the timber. In such instance, the water is vaporised with a high degree of efficiency while the remainder of the timber is not substantially affected by the radiation.

In the embodiment according to Fig. 5, the element 2 consists of an electric resistor 22 disposed centrally in the tube 17 and heated when current from the voltage source 11 passes through the resistor via conductors (not shown).

Fig. 6 shows a plate 18 which, in principle, is of the same construction as the tube 17 according to Fig. 5. Electric resistors 22 are embedded in the plate 18 and are

connected to a voltage source 11 via conductors 19. According to known technology, there is a plurality of examples of how, by suitable material selection and suitable current force, to obtain the working temperature of the radiation source which entails that the radiation is maximised within the wavelength interval at which water best absorbs radiation.

Thus, the elements 2 are made of a central electric resistor 22 surrounded by a tube 17, a plate 18 or the like.

The wavelength band has been selected at the range of approx. 2-20μm and as a rule approx. 5-20μm, a range which encompasses wavelengths at which the absorption of radiation by water is great. In such instance, use is made of the fact that, within these ranges, water has peaks with absorption coefficients higher than 1,000 cm^{-1}. The wood fibres are not susceptible for radiation at the above wavelengths and, thus, the wood as such will not be heated by the radiation.

The water has peaks at approx. 3μm, 6-7μm and 10-20μm regarding the absorption. Between approx. 7μm and 10μm the absorption coefficient of water is lower, sinking under 1,000 cm^{-1}. Thus, to maximise the effect of the radiation of the elements 2, they should have maximal intensity at the frequencies where water has maximal absorption, while the radiation at other wavelengths should be reduced.

Thus, one object of the present invention is to have a radiation with maximal intensity at the wavelengths where water has a high absorption coefficient, while the intensity is reduced at other wavelengths. The peak at 3μm is rather thin and demands a very high temperature and it is not feasible to use that for timber as the timber might get damaged. Furthermore, it is very hard and even virtually impossible, to reduce the radiation at the wavelength range approx. 4-6μm. In view of this the intensity of the radia-

tion of the elements is directed to the intervals approx. 6-7μm and 10-20μm and the intensity is reduced in the intermediate area, i.e. approx. 7-10μm. Thus, the energy of the radiation is used in a way to give maximal effect.

The intensity is dependant on the material of the elements according to the following formula:

$$I=I_0e^{-\alpha x}$$

,where I is the intensity, e is the natural logarithm and α is a constant depending on the material surrounding the resistor 22. By varying the material it is possible to control both the spectrum and the position of the radiation of the elements 2. This is used according to the present invention in such a way that the radiation of the elements 2 are adapted to the absorption of water as indicated above. Thus, according to the present invention the material surrounding the electrical resistor 22 is chosen to give the desired radiation spectrum of the element 2. Said material may be any material giving the desired properties..

In one embodiment which is illustrated in perspective in Fig. 7, a drying stack consists of a number of racks 5 alternating with timber 3 which is to be dried. One or more elements 2 are included in each rack 5 and, in the illustrated embodiment, consist of the tubes 17. These tubes 17 are shock-absorbed mounted in the frame of the rack 5. The Figure shows one embodiment in which several tubes are placed abreast. At least one of the racks 5 is provided with an electric socket 13 in order, via internal connections in and between the racks 5, to energise all elements 2. The electric socket 13 is connected to a voltage source 11 (Fig. 8). Further, the racks 5 have recesses 15 for a fork-lift truck in order that a drying stack may be driven into and out of the drying chamber 1 in a simple manner.

Fig. 7 shows one example of how a drying stack is built up. First, a rack 5 is placed in the bottom, whereafter a timber layer 16a is placed above the first rack 5.

Depending upon the thickness of the timber 3, a new rack 5 or an additional timber layer 16b is placed above the earlier timber layer. In the customary manner, laths 21 are placed between the timber layers. The build-up of the drying stack continues until the desired height is reached with alternating layering of racks 5 and timber layers.

Often, only a single layer of planks, boards etc., is placed between layers of elements 2. In other cases, such as for example with relatively heavy parts, it is possible to dispose two or more wood layers with laths 21 in between. In other embodiments, the disclosed distances vary depending upon type of element 2, wood type, dimensions, etc.

When a drying stack is ready to be dried, it is driven into the drying chamber, for example using a forklift truck. The drying stack is generally terminated by rack 5 uppermost. As a result of the design of the rack 5, it is possible, without major retrofitting and reconstruction, to employ the technique according to the present invention also in existing dryers. If space is available, it is possible to place several drying stacks adjacent one another. They may also be placed at an angle to each other.

In practical trials, it has proved that it is possible to obtain the desired drying of timber with good capacity and maintaining good quality also in applications where elements 2 are not included in the drying stacks. In stead they are only disposed at suitable positions within the chamber, such as on the walls and/or the ceiling of the drying chamber and/or between different stacks of timber.

In drying of timber in a drying apparatus according to Figs. 1-2 above, the process is regulated with the aid of the temperature in the wood 3. As a rule, the temperature is measured with an accuracy of ±1°C, at the same time as the relative humidity of the air is regulated and the moisture ratio of the wood is measured. When the moisture

ratio of the wood has fallen to fibre saturation, approx. 25-30%, the regulated temperature in the wood 3 is raised to a level, which depends upon wood type and quality. It is possible to maintain a high relative air humidity. The moisture given off by the wood is, as a rule, sufficient to maintain the air humidity at the desired level.

Using, as the most important regulation parameter, the temperature in the wood 3 entails that the wood 3 is supplied with precisely the energy needed to attain a certain drying temperature. Instead of measuring the temperature, it is, in principle, possible to measure the pressure in the wood, since the second derivate of the pressure is proportional to the temperature at constant volume. However, it is much simpler to measure the temperature.

Depending upon wood type and demand on quality of the dried wood, modifications may be made as regards, for example, heating times, drying temperature before fibre saturation, temperature elevation before final temperature, final temperature or moisture ratios.

It will be obvious to a person skilled in the art that the "constant" relative air humidity in the drying chamber is adapted to the properties of the wood type in question and, as a rule, within a relatively narrow range. For instance in the drying of oak, the air humidity is kept at approx. 85% ±4%. In the method according to the invention, it is important to maintain this high air humidity in the drying chamber 1 so as not to run the risk that the surface of the wood dries out. During the heating phase and at least initially in the drying phase, the relative air humidity is higher, it is often 100% or close to 100%.

In the drying, moisture is taken up from the surface of the wood 3 by the slowly circulating air in the drying chamber 1. When the moisture ratio of the wood has fallen to a level below approx. 10% or lower, the air humidity is, in a short final phase of the drying, raised for a brief

period in that the elements and fan are shut off. In such instance, the humidity in the wood is raised somewhat to the final desired moisture ratio of approx. 6-10%.

The above-mentioned example of temperatures and levels for moisture in the wood and air humidity are, as was mentioned, principally intended for oak. For other wood types, other values apply, but the principle is largely the same. For coniferous trees such as spruce, the drying period is considerably shorter than for deciduous trees.

A person skilled in the art will perceive that the foregoing constitutes merely examples of various regulation alternatives and that there are many more possible alternatives and modifications without departing from the scope of the appended claims.

As a result of the method and the apparatus according to the present invention, the drying times have been shorted by 40-50% compared with conventional drying at the same temperature. Moreover, the timber displays less crack formation and warping than in previously applied prior art technology. In that the present invention makes it possible to dry the timber 3 at a lower temperature than according to prior art methods, the likelihood that the timber displays colour changes and "pitch spotting" is also largely avoided.

The present invention discloses a technique for a method for drying wood, which has proved to be capable of being automated. The term automated is taken to signify that the drying process does not require the intervention of a machine operator, inspector or other similar person, but continues from beginning to end wholly automatically.

Taken as a whole, it may be ascertained that the present invention also discloses a technique that entails shorter drying time, lower energy consumption and reduced occurrence of crack formation and deformations in the timber on being dried.

The above detailed description has referred to only a limited number of embodiments of the present invention, but a person skilled in the art will readily perceive that the present invention encompasses a large number of embodiments without departing from the scope of the appended claims.

CLAIMS

1. A method for drying wood (3) in a drying chamber (1) employing air which passes the wood, where at least one element (2) disposed in the drying chamber emits thermal radiation, **characterized** in that during the drying phase the air is periodically at a temperature which is lower than or equal to the temperature of the wood and that the radiation encompasses those wavelengths at which water has peaks for absorption of radiation energy, with absorption coefficients which are greater than approx. 1,000 cm^{-1}.

2. The method as claimed in claim 1, **characterized** in that the radiation is concentrated to exact wavelength ranges where the water has absorption coefficient greater than approx. 1,000cm^{-1}, while the radiation is reduced in other areas.

3. The method as claimed in claim 3, **characterized** in that the radiation is concentrated to the wavelength ranges of approx. 6-7μm and approx. 10-20μm, while the radiation in the intermediate range, i.e. approx. 7-10μm is reduced.

4. The method as claimed in any of the previous claims, **characterized** in that for determining the prevailing moisture ratio of the wood, use is made of a weighing machine (27) and a calculation device (12) and/or that at least during the drying phase, the air humidity in the drying chamber (1) is substantially maintained by water or vaporised water departing from the wood (3).

5. The method as claimed in any of the preceding claims, **characterized** in that at least during the initial part of the drying phase, the relative humidity of the air in the drying chamber (1) is, in the drying of spruce, pine or wood possessing similar properties, kept at a level which is close to 100% and as a rule is located within the range of between 99% and 100%.

6. The method as claimed in any of the preceding claims, **characterized** in that the temperature and/or the

moisture ratio in the wood (3) and/or the air humidity in the drying chamber (1) is sensed in order to control the energisation or de-energisation of the elements (2).

7. The method as claimed in any of the preceding claims, **characterized** in that during parts of the drying cycle, said elements (2) are shut off; and that the length of the shut-offs and the time elapsing between such shut-offs of said elements are modified in accordance with the change of the moisture ratio of the wood.

8. An apparatus for drying wood (3) in a drying chamber (1) in accordance with the method as claimed in any of the previous claims, **characterized** in that the drying chamber includes at least one element (2) disposed in the drying chamber for emitting thermal radiation at wavelengths at which the absorption of radiation by the water is great; that a fan (4) is provided for the circulation of air in the drying chamber; that indicators (7, 8) are provided for sensing the temperature and/or moisture ratio in the wood (3); that indicators (9, 10) are provided for sensing the temperature and/or relative humidity of the air in the drying chamber (1); and that a control system (PLC system) is provided for controlling the elements (2) and the fan (4) in response to signals received from the indicators.

9. The apparatus as claimed in claim 8, **characterized** in that the elements (2) are mounted in racks (5) and that the racks (5) have surfaces displaying high reflectance.

10. The apparatus as claimed claim 8 or 9, **characterized** in that the drying chamber (1) is constructed from a chamber which, on the inside, is clad with plates of a material displaying high reflectance; that the drying chamber (1) is provided with a fan system (4) and a ventilation damper (14); that indicators (9, 10) are provided for sensing temperature and air humidity in the drying chamber (1); that indicators (27) are provided for sensing the weight of

the wood; and that the signals from all indicators (7-10, 27) are fed to a calculation and control device (12).

11. The apparatus as claimed in any of the claims 8 to 10, **characterized** in that the racks (5) with elements (2) are disposed to be placed on the walls of the chamber, and/or between stacks (6) of wood (3) which are to be dried and/or in such stacks; that the racks (5) with the elements (2) and the wood (3) which is to be dried are disposed in alternating layers; and that the elements (2) are tubular or plate-shaped.

12. The apparatus of claim 11, **characterized** in that each element (2) comprises an electrical resistor (22) surrounded by a tube (17), a plate (18) or the like.

13. The apparatus of claim 12, **characterized** in that the part surrounding the electrical resistor (22) is made of material having properties to give the desired radiation spectrum.

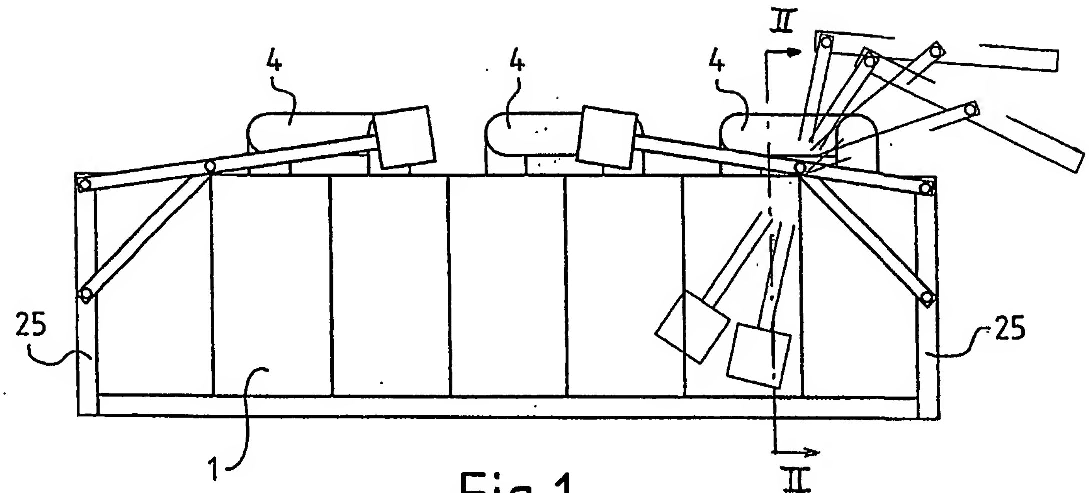

Fig.1

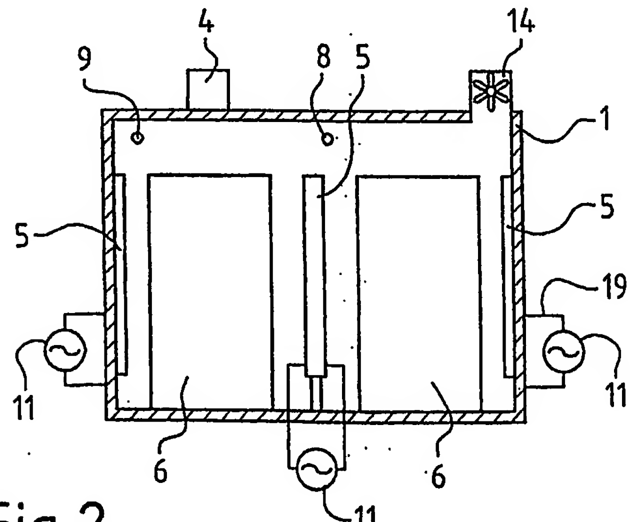

Fig.2

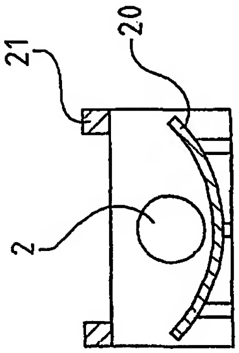

Fig.4

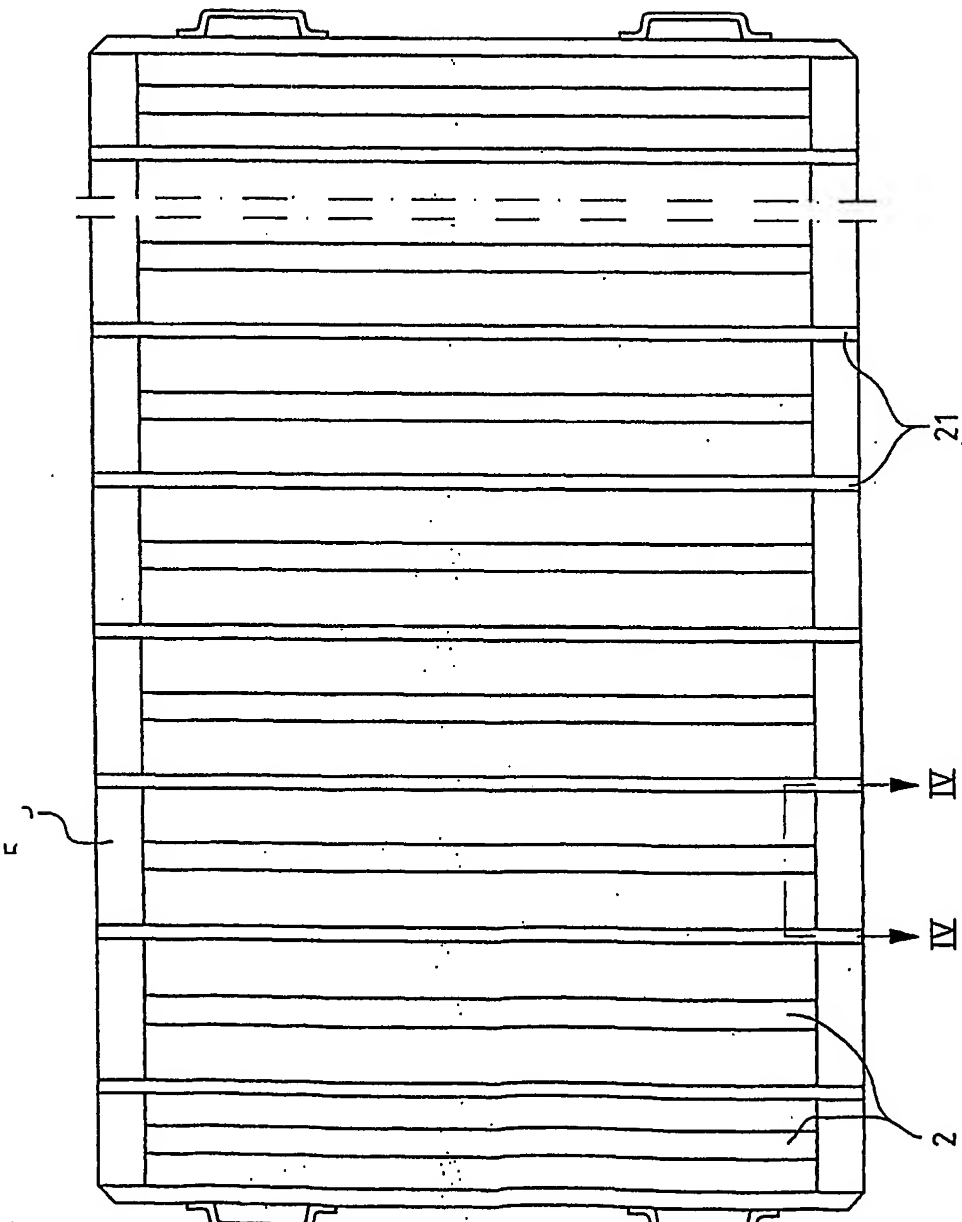

Fig.3

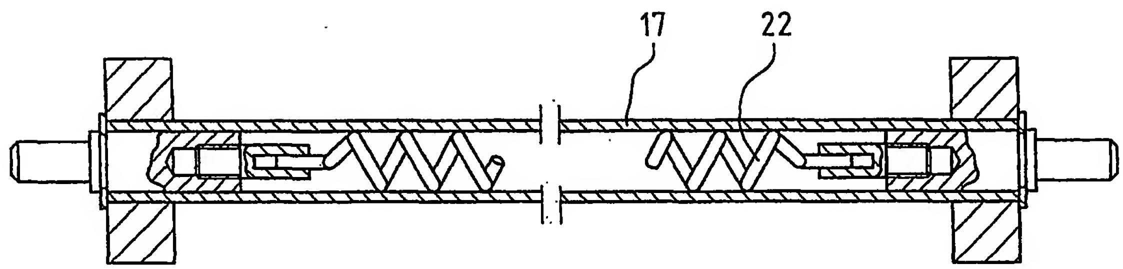

Fig.5

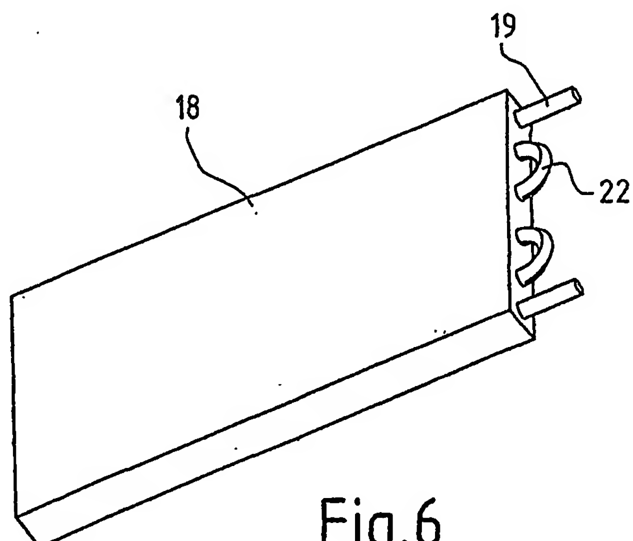

Fig.6

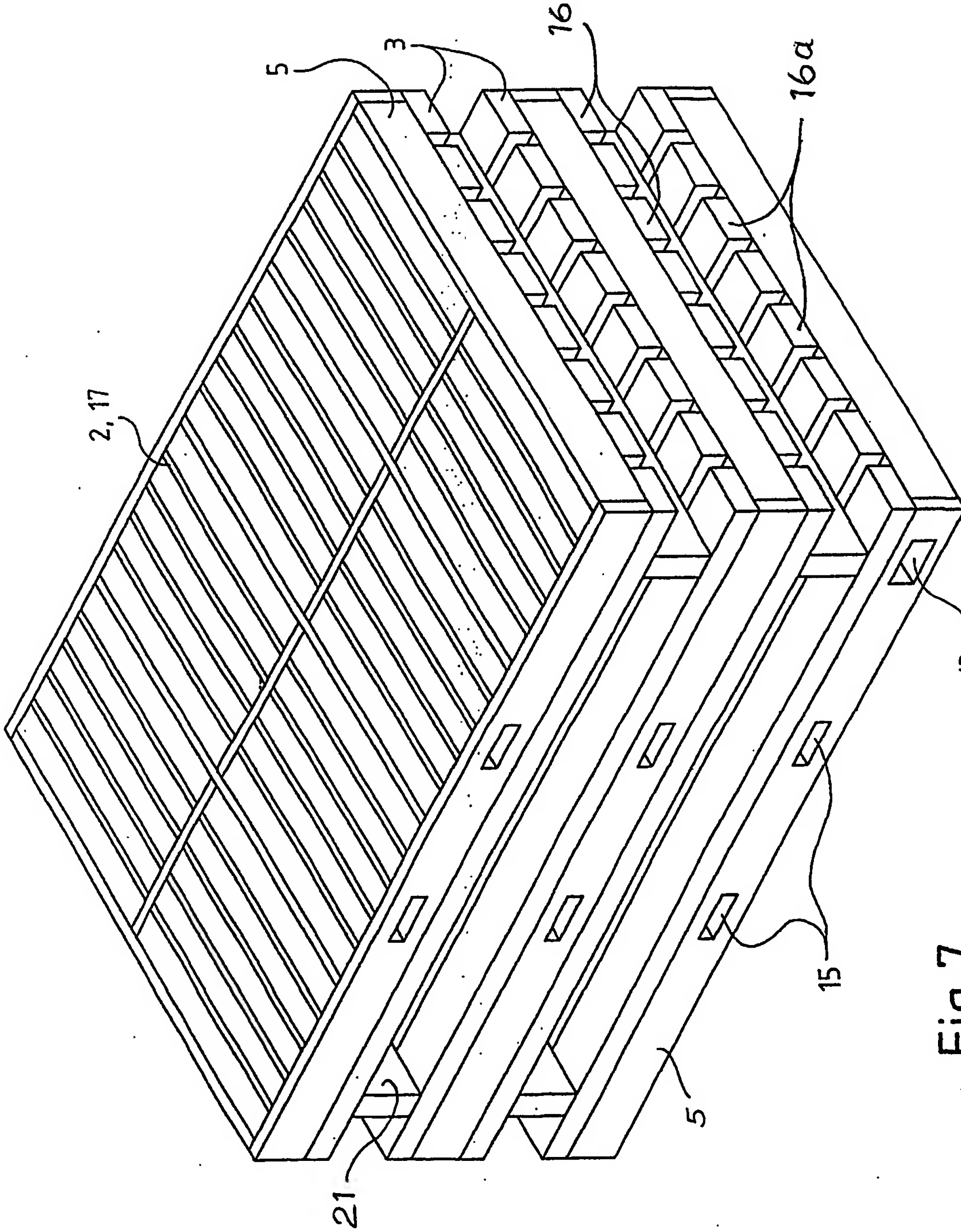

Fig.7

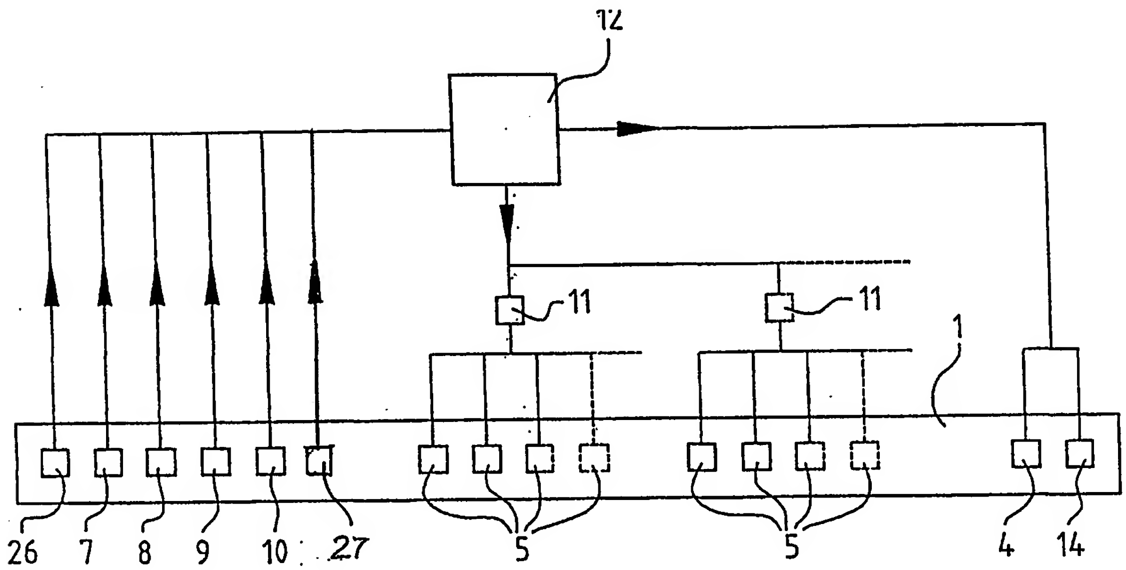

Fig.8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 01/02384

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: F26B 3/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: F26B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, EPODOC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 9812491 A1 (RAHIMOV, R. ET AL), 26 March 1998 (26.03.98), page 3, line 9 - line 15; page 11, line 23 - line 28, figures 1-5, abstract	1-3
Y	page 11, line 32 - line 34	4-13
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A	US 4488361 A (N.O.T. LÖÖF), 18 December 1984 (18.12.84), column 4, line 15 - line 27, claim 1, abstract	1-13
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Y	WO 9710482 A1 (MICROWAVE DRYING LIMITED), 20 March 1997 (20.03.97), page 4, line 8 - line 11; page 4, line 22 - line 24, claim 1, abstract	4-13
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 January 2002	14 -02- 2002

Name and mailing address of the ISA/	Authorized officer
Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Björn Salén / MRo Telephone No. +46 8 782 25 00

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3721013 A (D.G. MILLER), 20 March 1973 (20.03.73), figures 1-4, abstract	1-13

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INTERNATIONAL SEARCH REPORT
Information on patent family members

27/12/02

International application No.
PCT/SE 01/02384

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US 3721013 A	20/03/73	NONE	